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Jurisdictional spillover effects of sprawl on injuries and fatalities

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ABSTRACT

There is a considerable literature on the relationship between sprawl and accidents. However, these studies do not account for the spatially correlated effects of sprawl on accidents. In our analysis of 122 jurisdictions in Southeast Michigan, we use a Bayesian spatial autoregressive model to estimate how injuries and fatalities in one jurisdiction are associated with sprawl in that jurisdiction and sprawl in neighboring jurisdictions; we also correct for heteroskedasticity in the data. Using principal component analysis, we create a sprawl index from five underlying land use characteristics. Our results show that the number of injuries and fatalities in a jurisdiction increases with the magnitude of sprawl in neighboring jurisdictions. We believe that this is because more drivers per capita in sprawled jurisdictions traverse similarly sprawled neighboring jurisdictions for daily activities. Furthermore, driving habits attuned to less defensive driving in sprawled jurisdiction are transferred to similarly designed neighboring jurisdictions, contributing to accidents in the latter.

1. Introduction

For some time now, the literature has expressed concerns about the relationship between transportation safety and land use sprawl. The concern is that sprawl may lead to more accidents. Indeed, several studies have shown that sprawl can be associated with more traffic injuries and fatalities (for reviews, see, e.g., Ewing and Cervero, 2010; Ewing and Dumbaugh, 2009). However, many of these studies rely on simple ordinary least square regression, do not control for the degree of sprawl (as noted by Ewing and Dumbaugh, 2009) or, if they do control for sprawl, are performed at coarse levels of geography (as noted by Ewing et al., 2003).

More importantly, these studies do not account for the possibility of spatially correlated effects of sprawl on accidents. They treat the relationship between sprawl and accidents as a local phenomenon; that is, accidents in jurisdiction *A* are a function of sprawl *only* in jurisdiction *A*. However, as we will discuss later, we believe that sprawl in one jurisdiction affects accidents in adjacent jurisdictions. To assess this possibility, we use a Bayesian spatial autoregressive (SAR) model to estimate how injuries and fatalities in jurisdiction *A* are associated with sprawl in jurisdiction *A* and sprawl in adjacent jurisdictions, and we correct for heteroskedasticity in the data. While a number of studies have examined the presence of spatial correlation in accidents (see, e.g., Quddus, 2008), as far as we know none have extended these studies to examine the relationship between sprawl and accidents. Because prior studies ignore such spatial correlation, their OLS parameter estimates may be biased and inconsistent.

In addition to the methodological improvements outlined above, we use a measure of sprawl based on the innovative approach of Ewing et al. (2003). This approach uses principal component analysis to provide a measure of sprawl based on underlying land use characteristics. Our study also accounts for more control variables than other similar papers. Finally, to examine finer grains of geography, we perform our analysis at the city and township level.

We perform our analysis in Southeast Michigan, an area whose land use policies have been understudied even though it is considered a bellwether for land use outcomes in many Midwestern states (Boyle and Mohamed, 2007). The area is also interesting because of its stalled attempts to implement regional transportation planning initiatives (Boyle and Mohamed, 2007), an issue that is pertinent to the policy recommendations implied by our findings.

Our results are consistent with our hypothesis that sprawl in one jurisdiction is associated with more accidents in neighboring jurisdictions. To our knowledge, this is the first time that results of this type have been presented. We offer the following explanations for our results: (1) jurisdictions with higher degrees of sprawl tend to be clustered (see later discussions), which leads to cross-jurisdictional traffic, and (2) these sprawled jurisdictions likely have similar design characteristics, so drivers moving from one jurisdiction to a neighboring jurisdiction do not encounter

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design cues that encourage defensive driving. Our results suggest that regional initiatives to address sprawl can reduce the number of traffic injuries and fatalities, but more precise recommendations require an understanding of where accidents occur in sprawled, clustered jurisdictions, whether on major and arterial roads or local roads.

Before we proceed, one caveat is warranted: we do not investigate the effects of road design on accidents. We make this point because we realize that recent literature emphasizes the importance of design (see, e.g., Dumbaugh and Rae, 2009). Our article focuses on how accidents in a jurisdiction are affected by sprawl in adjacent jurisdictions. We note that Dumbaugh and Rae (2009) deliberately ignore the effects of spatial autocorrelation because of the technical issues involved in simultaneously addressing both spatial autocorrelation and design. Nonetheless, following the literature that we review, we do emphasize the importance of road design in our recommendations to reduce the spillover effects of sprawl on accidents.

This article proceeds as follows. In Section 2, we briefly discuss the vast literature on land use and accidents. In Section 3, we discuss the study area and our data. Section 4 describes our model specification. Section 5 presents our results; in Section 6, we present conclusions and planning recommendations.

2. Land use, sprawl, and accidents

There are numerous "crash prediction" studies (Hadayeghi et al., 2003). These studies—many of which come from the civil engineering literature—have been useful in highlighting factors that lead to accidents. These factors range from population characteristics such as age (Laflamme and Diderichsen, 2000) and socioeconomic status (Laflamme and Diderichsen, 2000) to the amount of travel within a geographic unit (Lovegrove and Sayed, 2007).

Other studies link accidents to urban form. There are many definitions of urban form, such as simple measures of population density (Clark and Cushing, 2004, although they examine only rural accidents) to more complicated measures of street density (Marshall and Garrick, 2011) and intersection density (de Guevara et al., 2004; Siddiqui et al., 2012). More recently, scholars have expanded definitions of urban form to take account of a variety of other design factors such as traditional grid layouts versus loops, curves, and cul-de-sacs (Rifaat et al., 2011); street widths, building mass, and setbacks (Jones and Jha, 2010); and the design of arterial roads (Dumbaugh and Rae, 2009). Although the results are not unanimous, the vast majority of studies show that denser populations, denser street networks, narrower streets, and traditional street grid designs result in fewer accidents (Ewing and Dumbaugh, 2009).

Scholars have also attempted to account for the multifaceted nature of design and density and their relationship to sprawl (see, e.g., Galster et al., 2001). With this recognition, Ewing et al. (2003) blended different measures to create a "sprawl index." They then examined the relationship between this index and accidents. Their findings mirror those discussed earlier: sprawling areas are associated with more traffic and pedestrian fatalities.

The use of indices to examine the relationship between sprawl and accidents or accident-related phenomena has grown. For example, Trowbridge and McDonald (2008) and Trowbridge et al. (2009) constructed similar indices to show that sprawl is associated with more teen driving and longer ambulance arrival times, respectively. In both papers, the authors conclude that sprawl can lead to more traffic fatalities. Using another index of sprawl, Lambert and Meyer (2006) and Lucy (2003) also find that sprawl is associated with more accidents.

There are two underlying reasons that sprawl is associated with more accidents. First, less dense areas require more travel per capita (see, e.g., Levine et al., 1995). Second, sprawling areas encourage higher speeds and discourage defensive driving (Zegeer et al., 2002). On the other hand, as Ewing and Dumbaugh (2009) discuss in their review of the empirical literature, denser areas provide esthetic cues that encourage slower and safer driving, leading to fewer accidents. For example, narrow lanes (Huang et al., 2002; Noland and Oh, 2004) and traffic calming devices such as speed tables (Ewing, 2001) have been found to reduce the number of accidents. Esthetic streetscapes alongside roadways have been found to have the same effect (Naderi, 2003). Similarly, Lee and Mannering (2002) find that in urban areas, trees are associated with a decrease in accidents. In short, drivers respond to design cues offered by the built environment.[1]

Although the studies outlined above have made important contributions to our understanding of the relationship between sprawl and accidents, fewer studies examine how sprawl spills over from one jurisdiction to another. To be sure, there is a growing number of studies that examine whether accidents are spatially correlated (see, e.g., El-Basyouny and Sayed, 2009; Huang et al., 2010; Quddus, 2008), but there is a lack of studies that examine spatial autocorrelation of sprawl to ascertain how sprawl in one jurisdiction can contribute to accidents in neighboring jurisdictions.

3. The study area and data

We study the seven-county area (Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw, and Wayne) that comprises the Southeast Michigan Council of Governments (SEMCOG), the region's metropolitan planning agency. Our study area was chosen partially because we had access to accident data collected by SEMCOG for 124 communities located within its borders. However, Southeast Michigan is interesting for additional reasons. Although Michigan does not feature prominently in the national discussions about how to respond to land use sprawl, the state—particularly the southeast region of which SEMCOG is a part—is in the midst of vigorous debates about how to cope with economic disruption and a shrinking central city, Detroit (Boyle and Mohamed, 2007; Mohamed, 2008).

As they engage in these debates, policy makers and civic advocates are also discussing several related issues: funding for road repairs (Egan, 2013), revitalization of Detroit's central business district (Gallagher, 2013), and regional transportation options (Helms, 2013), a debate that is itself part of the first two debates. To be sure, debates similar to those in Southeast Michigan are playing out in different forms across the nation, in places such as Cleveland, Pittsburgh, Indianapolis, etc., but these metropolitan regions do not have a central city that has declined as severely as Detroit, nor do they suffer from the same level of segregation, both economic and racial, as Detroit (for reviews of these discussions, see, e.g., Nelson and Lang, 2011). Results from this study therefore hold important lessons for these other regions as they seek to avoid the fate of Southeast Michigan.

We obtained data on accidents for the year 2010 from SEMCOG. These data include the number of accidents that resulted in injuries and fatalities, which is our dependent variable of interest. Because of spatial correlation in the data, which we will discuss later, and because of the approach we use to correct for this problem, we dropped two of the 124 jurisdictions for which we had data because they were not contiguous with at least one other jurisdiction. Thus, we were left with 122 jurisdictions to analyze (see Fig. 1).

[1] While researchers do not understand all the reasons certain design cues lead to fewer accidents, the phenomenon appears to have a psychological basis (Dumbaugh and Rae, 2009).